

Exhibit 10

N. GREGORY MANKIW

PRINCIPLES OF MICROECONOMICS

Eighth Edition



FIRM BEHAVIOR AND THE ORGANIZATION OF INDUSTRY

- | | | | |
|----|------------------------------|---|---|
| 13 | The Costs of Production | — | <i>The theory of the firm sheds light on the decisions that lie behind supply in competitive markets.</i> |
| 14 | Firms in Competitive Markets | | |
| 15 | Monopoly | — | <i>Firms with market power can cause market outcomes to be inefficient.</i> |
| 16 | Monopolistic Competition | | |
| 17 | Oligopoly | | |

THE ECONOMICS OF LABOR MARKETS

- | | | | |
|----|---|---|--|
| 18 | The Markets for the Factors of Production | — | <i>These chapters examine the special features of labor markets, in which most people earn most of their income.</i> |
| 19 | Earnings and Discrimination | | |
| 20 | Income Inequality and Poverty | | |

TOPICS FOR FURTHER STUDY

- | | | | |
|----|-------------------------------|---|--|
| 21 | The Theory of Consumer Choice | — | <i>Additional topics in microeconomics include household decision making, asymmetric information, political economy, and behavioral economics.</i> |
| 22 | Frontiers of Microeconomics | | |

PRINCIPLES OF
MICROECONOMICS

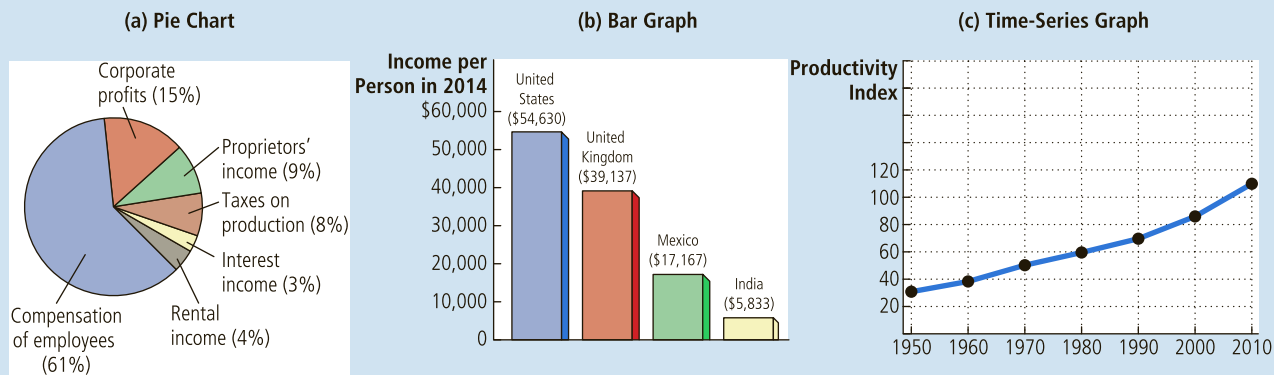
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FIGURE A-1**Types of Graphs**

The pie chart in panel (a) shows how U.S. national income is derived from various sources. The bar graph in panel (b) compares the average income in four countries. The time-series graph in panel (c) shows the productivity of labor in U.S. businesses over time.



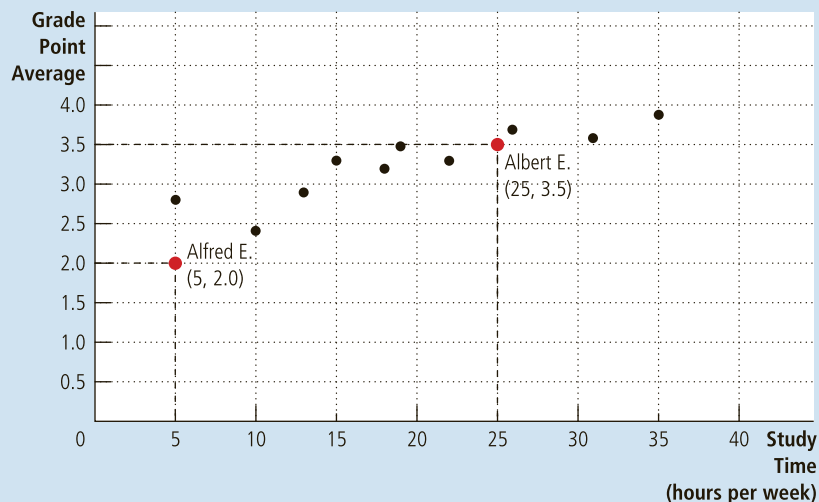
while his “what-me-worry?” classmate Alfred E. is represented by the ordered pair (5 hours/week, 2.0 GPA).

We can graph these ordered pairs on a two-dimensional grid. The first number in each ordered pair, called the *x-coordinate*, tells us the horizontal location of the point. The second number, called the *y-coordinate*, tells us the vertical location of the point. The point with both an *x-coordinate* and a *y-coordinate* of zero is known as the *origin*. The two coordinates in the ordered pair tell us where the point is located in relation to the origin: *x* units to the right of the origin and *y* units above it.

Figure A-2 graphs grade point average against study time for Albert E., Alfred E., and their classmates. This type of graph is called a *scatter plot* because it plots

FIGURE A-2**Using the Coordinate System**

Grade point average is measured on the vertical axis and study time on the horizontal axis. Albert E., Alfred E., and their classmates are represented by various points. We can see from the graph that students who study more tend to get higher grades.



scattered points. Looking at this graph, we immediately notice that points farther to the right (indicating more study time) also tend to be higher (indicating a better grade point average). Because study time and grade point average typically move in the same direction, we say that these two variables have a *positive correlation*. By contrast, if we were to graph party time and grades, we would likely find that higher party time is associated with lower grades. Because these variables typically move in opposite directions, we say that they have a *negative correlation*. In either case, the coordinate system makes the correlation between two variables easy to see.

Curves in the Coordinate System

Students who study more do tend to get higher grades, but other factors also influence a student’s grades. Previous preparation is an important factor, for instance, as are talent, attention from teachers, even eating a good breakfast. A scatter plot like Figure A-2 does not attempt to isolate the effect that studying has on grades from the effects of other variables. Often, however, economists prefer looking at how one variable affects another, holding everything else constant.

To see how this is done, let’s consider one of the most important graphs in economics: the *demand curve*. The demand curve traces out the effect of a good’s price on the quantity of the good consumers want to buy. Before showing a demand curve, however, consider Table A-1, which shows how the number of novels that Emma buys depends on her income and on the price of novels. When novels are cheap, Emma buys them in large quantities. As they become more expensive, she instead borrows books from the library or chooses to go to the movies rather than read. Similarly, at any given price, Emma buys more novels when she has a higher income. That is, when her income increases, she spends part of the additional income on novels and part on other goods.

We now have three variables—the price of novels, income, and the number of novels purchased—which is more than we can represent in two dimensions. To put the information from Table A-1 in graphical form, we need to hold one of the three variables constant and trace out the relationship between the other two. Because the demand curve represents the relationship between price and quantity demanded, we hold Emma’s income constant and show how the number of novels she buys varies with the price of novels.

Price	For \$30,000 Income:	For \$40,000 Income:	For \$50,000 Income:
\$10	2 novels	5 novels	8 novels
9	6	9	12
8	10	13	16
7	14	17	20
6	18	21	24
5	22	25	28
	Demand curve, D_3	Demand curve, D_1	Demand curve, D_2

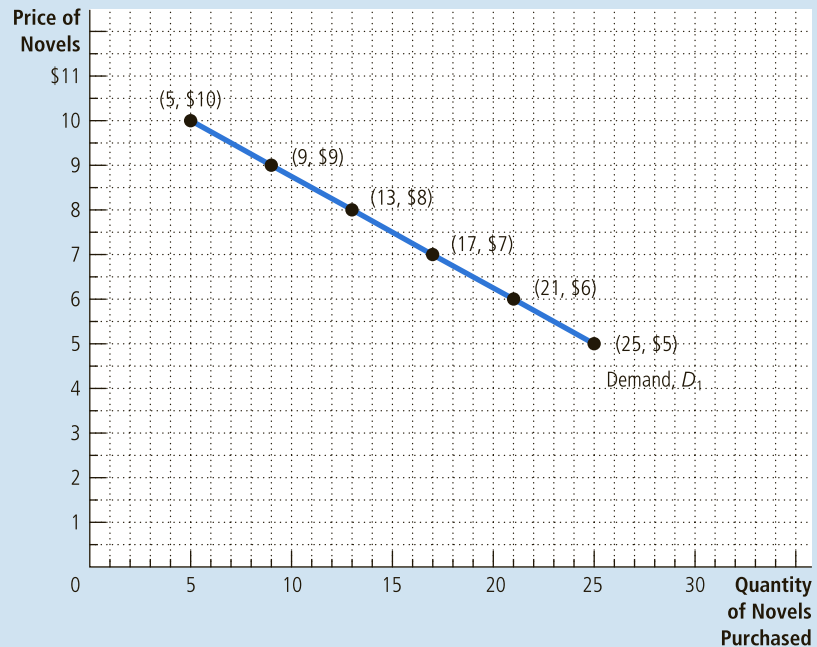
TABLE A-1

Novels Purchased by Emma

This table shows the number of novels Emma buys at various incomes and prices. For any given level of income, the data on price and quantity demanded can be graphed to produce Emma’s demand curve for novels, as shown in Figures A-3 and A-4.

FIGURE A-3**Demand Curve**

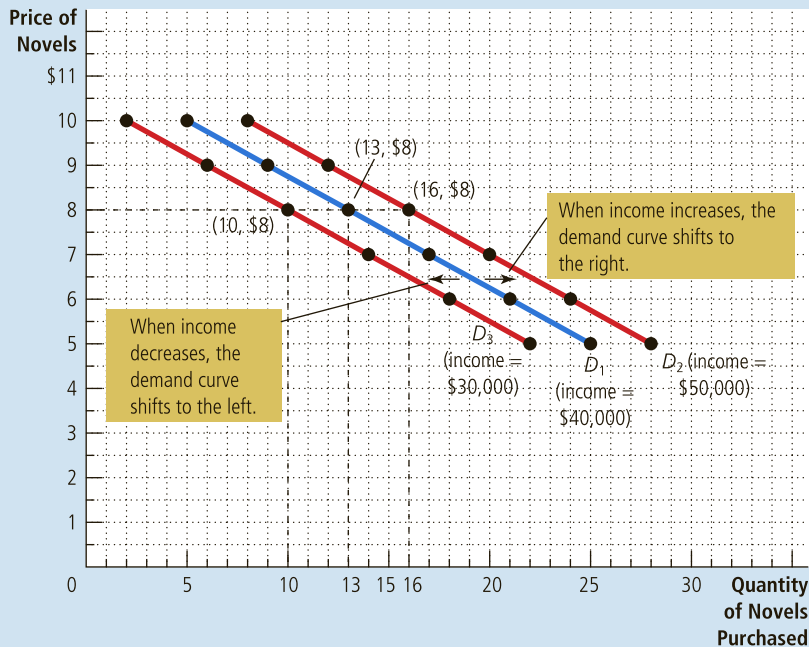
The line D_1 shows how Emma's purchases of novels depend on the price of novels when her income is held constant. Because the price and the quantity demanded are negatively related, the demand curve slopes downward.



Suppose that Emma's income is \$40,000 per year. If we place the number of novels Emma purchases on the x -axis and the price of novels on the y -axis, we can graphically represent the middle column of Table A-1. When the points that represent these entries from the table—(5 novels, \$10), (9 novels, \$9), and so on—are connected, they form a line. This line, pictured in Figure A-3, is known as Emma's demand curve for novels; it tells us how many novels Emma purchases at any given price, holding income constant. The demand curve is downward-sloping, indicating that a higher price reduces the quantity of novels demanded. Because the quantity of novels demanded and the price move in opposite directions, we say that the two variables are *negatively related*. (Conversely, when two variables move in the same direction, the curve relating them is upward-sloping, and we say that the variables are *positively related*.)

Now suppose that Emma's income rises to \$50,000 per year. At any given price, Emma will purchase more novels than she did at her previous level of income. Just as earlier we drew Emma's demand curve for novels using the entries from the middle column of Table A-1, we now draw a new demand curve using the entries from the right column of the table. This new demand curve (curve D_2) is pictured alongside the old one (curve D_1) in Figure A-4; the new curve is a similar line drawn farther to the right. We therefore say that Emma's demand curve for novels *shifts* to the right when her income increases. Likewise, if Emma's income were to fall to \$30,000 per year, she would buy fewer novels at any given price and her demand curve would shift to the left (to curve D_3).

In economics, it is important to distinguish between *movements along a curve* and *shifts of a curve*. As we can see from Figure A-3, if Emma earns \$40,000 per year and novels cost \$8 apiece, she will purchase 13 novels per year. If the price of

**FIGURE A-4****Shifting Demand Curves**

The location of Emma's demand curve for novels depends on how much income she earns. The more she earns, the more novels she will purchase at any given price, and the farther to the right her demand curve will lie. Curve D_1 represents Emma's original demand curve when her income is \$40,000 per year. If her income rises to \$50,000 per year, her demand curve shifts to D_2 . If her income falls to \$30,000 per year, her demand curve shifts to D_3 .

novels falls to \$7, Emma will increase her purchases of novels to 17 per year. The demand curve, however, stays fixed in the same place. Emma still buys the same number of novels *at each price*, but as the price falls, she moves along her demand curve from left to right. By contrast, if the price of novels remains fixed at \$8 but her income rises to \$50,000, Emma increases her purchases of novels from 13 to 16 per year. Because Emma buys more novels *at each price*, her demand curve shifts out, as shown in Figure A-4.

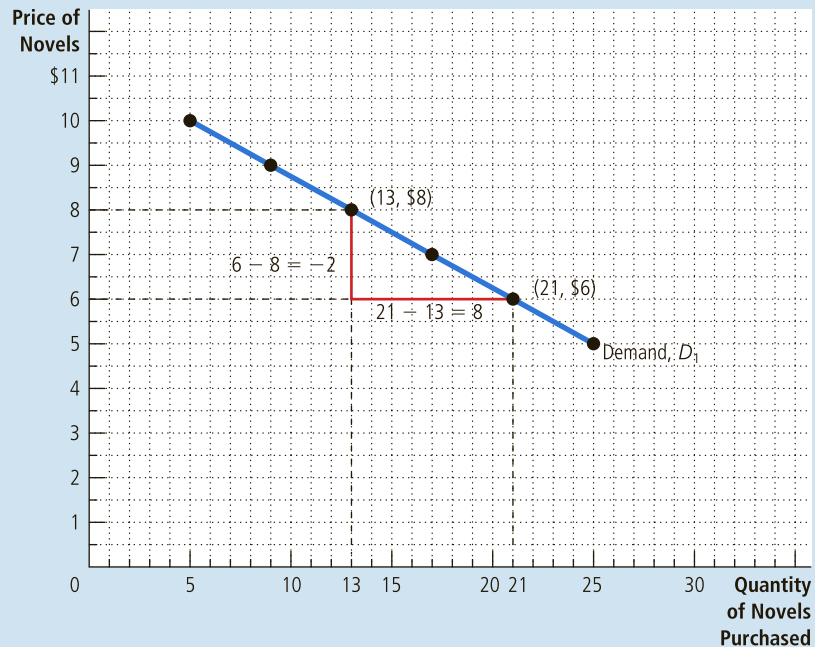
There is a simple way to tell when it is necessary to shift a curve: *When a relevant variable that is not named on either axis changes, the curve shifts.* Income is on neither the x -axis nor the y -axis of the graph, so when Emma's income changes, her demand curve must shift. The same is true for any change that affects Emma's purchasing habits, with the sole exception of a change in the price of novels. If, for instance, the public library closes and Emma must buy all the books she wants to read, she will demand more novels at each price, and her demand curve will shift to the right. Or if the price of movies falls and Emma spends more time at the movies and less time reading, she will demand fewer novels at each price, and her demand curve will shift to the left. By contrast, when a variable on an axis of the graph changes, the curve does not shift. We read the change as a movement along the curve.

Slope

One question we might want to ask about Emma is how much her purchasing habits respond to price. Look at the demand curve pictured in Figure A-5. If this curve is very steep, Emma purchases nearly the same number of novels regardless

FIGURE A-5**Calculating the Slope of a Line**

To calculate the slope of the demand curve, we can look at the changes in the x - and y -coordinates as we move from the point (21 novels, \$6) to the point (13 novels, \$8). The slope of the line is the ratio of the change in the y -coordinate (-2) to the change in the x -coordinate ($+8$), which equals $-\frac{1}{4}$.



of whether they are cheap or expensive. If this curve is much flatter, the number of novels Emma purchases is more sensitive to changes in the price. To answer questions about how much one variable responds to changes in another variable, we can use the concept of *slope*.

The slope of a line is the ratio of the vertical distance covered to the horizontal distance covered as we move along the line. This definition is usually written out in mathematical symbols as follows:

$$\text{slope} = \frac{\Delta y}{\Delta x},$$

where the Greek letter Δ (delta) stands for the change in a variable. In other words, the slope of a line is equal to the “rise” (change in y) divided by the “run” (change in x). The slope will be a small positive number for a fairly flat upward-sloping line, a large positive number for a steep upward-sloping line, and a negative number for a downward-sloping line. A horizontal line has a slope of zero because in this case the y -variable never changes; a vertical line is said to have an infinite slope because the y -variable can take any value without the x -variable changing at all.

What is the slope of Emma’s demand curve for novels? First of all, because the curve slopes down, we know the slope will be negative. To calculate a numerical value for the slope, we must choose two points on the line. With Emma’s income at \$40,000, she will purchase 21 novels at a price of \$6 or 13 novels at a price of \$8. When we apply the slope formula, we are concerned with the change between these two points. In other words, we are concerned with the difference between